Prasanna BALAPRAKASH

Laboratory for Advanced Numerical Simulation
Mathematics and Computer Science Division
Argonne National Laboratory
Bldg. 240, Room. 1129
9700 S. Cass Avenue, Argonne, IL 60439
Phone: (630) 252-1109
E-mail: pbalapra@mcs.anl.gov
URL: www.mcs.anl.gov/~pbalapra

SCIENTIFIC EXPERTISE

Stochastic combinatorial optimization, High performance computing, Automatic tuning, Derivative free optimization, Stochastic local search algorithms, Rare-event simulation, and Statistical analysis.

PROFESSIONAL EXPERIENCE

Divisional Postdoctoral Researcher September 2010–Present
Supervisors: Dr. Stefan Wild and Dr. Paul Hovland
Laboratory for Advanced Numerical Simulation
Mathematics and Computer Science Division
Argonne National Laboratory, IL

- I am involved in the Communication Avoidance and Communication Hiding at the Extreme Scale project. As advanced supercomputers move to the extreme scale, customary compiler optimization techniques will become both prohibitively expensive and unable to achieve the levels of performance gains needed. This is because the number of decision parameters that must be chosen rapidly grows as codes and architectures become more complex, and the computational expense of running these codes rules out enumeration. My research in automatic tuning of computer codes will help overcome these limitations by directly optimizing the performance of the codes on the desired extreme scale machine. The main goal of my research work is to develop effective optimization methods for automatic tuning of high performance computing codes on future extreme scale architectures.

Chief Technology Officer January 2009–August 2010
Mentis Consulting Sprl, Brussels, Belgium

- Led artificial intelligence and operations research project developments. Researched the market for R&D consulting in Belgium. Launched data analytics service for process industries to tackle environmental, energy, and efficiency challenges. Increased the revenue of Mentis Consulting Sprl by 15%. Suggested and reviewed new business strategy and plans. Advised the CEOs.
- Modeling and prediction of power plant combustion for a leading energy industry, Belgium.

  Principal data analyst: Assessed the high dimensional historic data with analysis of variance and random forest techniques to identify important factors that affect nitrogen oxide emission in a power plant combustion process. Used R with stats and Breiman and Cutler's random forests libraries.

  Rapid prototype developer: Implemented a prediction method based on the random forest that has achieved an accuracy of up to 80%. Developed a genetic algorithm on top of the prediction model to identify optimal operating levels. Identified appropriate parameter values of genetic algorithm using Iterative F-Race, an offline algorithm tuning procedure. Procured an expected reduction in nitrogen oxide emission up to 2%. Used R with gafit libraries.

- Resource optimization for a glass manufacturing industry, Belgium.

  Principal data analyst: Evaluated the experimental data with multivariate analysis of variance and studied the impact of raw material composition on the glass reflection properties. Identified and eliminated two insignificant raw materials. Used R with stats library and Rapid miner tool set.

  Rapid prototype developer: Developed a hybrid prediction method based on generalized linear models and regression tress. Designed a multi objective genetic algorithm to identify promising raw material compositions. Deployed Iterative F-Race for algorithm tuning. Reduced the expected resources needed for glass manufacturing by 5%. Used R with glm and tree libraries.

FORMAL EDUCATION

Doctor of Philosophy in Engineering Sciences November 2004–January 2010
Focus: Stochastic Optimization, Metaheuristics, and Automatic Algorithm Tuning
Thesis: Estimation-based metaheuristics for stochastic combinatorial optimization
Supervisors: Prof. Marco Dorigo, Dr. Mauro Birattari, and Dr. Thomas Stützle
Artificial Intelligence Lab (IRIDIA), Université Libre de Bruxelles, Belgium

- Proposed a new engineering framework for design, analysis, and implementation of metaheuristic and local search algorithms that deploy Monte Carlo simulation and inferential statistics to tackle large-scale stochastic routing problems. Developed new simulation-based ant colony optimization, genetic algorithm, and iterated local search. Implementations of the proposed algorithms reduced the time needed for the task by 3 orders of magnitude without significant loss in solution quality. The proposed simulation-based algorithms are currently the state-of-the-art in the field.
- Developed Iterative F-Race, an offline automatic algorithm tuning procedure based on machine learning techniques to identify appropriate values for the parameters of search algorithms. Iterative F-Race played a crucial role to achieve state-of-the-art algorithms for the stochastic routing problems. Deployed Iterative F-Race to tune an iterated greedy algorithm developed for a complex locomotive scheduling problem at a railway company. Automatic tuning reduced the time required for the tuning task by a factor of 8.

Master of Philosophy (Belgian D.E.A.) in Applied Sciences November 2004–September 2005
Focus: Simulation Optimization and Metaheuristics
Thesis: Ant colony optimization under uncertainty
Supervisors: Prof. Marco Dorigo and Dr. Mauro Birattari
Artificial Intelligence Lab (IRIDIA), Université Libre de Bruxelles, Belgium

- Self-taught the fundamentals of optimization algorithms and stochastic routing problems. Proposed ACO/F-Race, a new simulation-based ant colony optimization algorithm. Implemented the algorithm in C under Linux. Assessed the results and performed statistical tests in R. Procured a grade of 18/20 for the research work (Scale: 20=Maximum,. . ., 10=Pass).

Master of Science in Computer Science October 2002–May 2004
Focus: Modeling and Simulation
Thesis: Preprocessing of stochastic Petri nets and improved storage strategy for proxel based simulation
Supervisors: Prof. Graham Horton and Dr. Sanja Lazarova-Molnar
Otto-von-Guericke Universität Magdeburg, Germany

- Developed a new automation module and storage strategy for proxel-based simulation, a rare-event simulation method used to analyze a particular cost warranty model. Reduced the manual work involved in the modeling phase by 50% and the computation time required for the simulation by a factor of 4. Implemented the automation module and the storage strategy in Java under Windows. Achieved a grade of 1.6 for the thesis (Scale: 1=Maximum,. . ., 4=Pass).

Bachelor of Engineering in Computer Science June 1998–May 2002
Periyar University, India

Awards and Fellowships

- **F.N.R.S. Chargé de recherches fellowship** from the Belgian Funds for Scientific Research from October 2010 to September 2013. (One of the most competitive postdoctoral fellowships in Belgium. Declined to accept postdoc at Argonne National Laboratory.)
- **F.N.R.S. Aspirant fellowship** from the Belgian Funds for Scientific Research, from October 2006 to September 2008. (One of the most competitive Ph.D. fellowships in Belgium.)
- **Marie Curie fellowship** from the European Commission through the fifth framework human resources and mobility program, from November 2004 to September 2006. (One of the most competitive Ph.D. fellowships at the European level.)
- **International student scholarship** for the best academic performance from Otto-von-Guericke Universität Magdeburg, Germany, from April 2003 to March 2004. (Scholarship awarded every year to the top two international students.)
- Procured **First class with Distinction** degree from Periyar University, India, May 2002.

Research Assistantships

Research Assistant July 2003–June 2004
M-BiS GmbH, Magdeburg, Germany

- Teamed up for the research and development of LAURA, an enterprise resource planning software for small-scale enterprises. Drafted the initial software design for customizable internationalization module for LAURA and played a core role in the Java implementation. M-BiS GmbH increased its revenue by 4% using the developed module.

Research Assistant December 2002–February 2003
Institute for Material Science and Engineering
Otto-von-Guericke Universität Magdeburg, Germany

- Self-taught the advanced concepts of image processing. Developed a new computational micro structure analyzing algorithm to reduce the manual work involved in the process from 1 week to 5 hours. Published the proposed algorithm in a journal with the researchers.

Selected Software Skills

- C, C++, and Python (under Linux and Windows)
- R & Matlab programming language and software environment

Editorial Activities

Peer-reviewed manuscripts in journals such as IEEE Transactions on Evolutionary Computation, INFORMS Journal of Computing, European Journal of Operations Research, Journal of Computers and Operations Research, Journal of Heuristics, and Journal of Swarm Intelligence. Served as a peer-reviewer for more than 15 conferences such as MICAI 2006, MIC 2005, HM 2005, GECCO 2005, ANTS 2006, HM 2006, ICINCO 2007, GECCO 2007, ICANNGA 2007, and WEA 2007.

Organizational Activities

Organized optimization monthly meeting and seminars in IRIDIA while maintaining a close coordination with three senior researchers and seven Ph.D. students. Teamed up for organizing three workshops: first workshop on Stochastic Local Search Engineering Brussels, Belgium, 2007; fifth and sixth International Workshop on Ant Colony Optimization and Swarm Intelligence, Brussels, Belgium, 2006 and 2008.

Language Skills

English (Fluent), French (Intermediate), and German (Beginner).

Publications

Journal articles

1. **P. Balaprakash**. Estimation-based metaheuristics for stochastic combinatorial optimization: Case studies in stochastic routing problems. *ACM SIGEVOlution*, 5(1):18–19, 2010.

2. **P. Balaprakash**, M. Birattari, T. Stützle, and M. Dorigo. Estimation-based metaheuristics for the probabilistic traveling salesman problem. *Computers and Operations Research*, 37(11):1939–1951, 2010.

3. **P. Balaprakash**, M. Birattari, T. Stützle, Z. Yuan, and M. Dorigo. Estimation-based ant colony optimization and local search for the probabilistic traveling salesman problem. *Swarm Intelligence*, 3(3):223–242, 2009.

4. **P. Balaprakash**, M. Birattari, T. Stützle, and M. Dorigo. Adaptive sample size and importance sampling in estimation-based local search for the probabilistic traveling salesman problem. *European Journal of Operational Research*, 199(1):98–110, 2009.

5. M. Birattari, **P. Balaprakash**, T. Stützle, and M. Dorigo. Estimation-based local search for stochastic combinatorial optimization using delta evaluations: A case study in the probabilistic traveling salesman problem. *INFORMS Journal on Computing*, 20(4):644–658, 2008.

6. D.G. Leo Prakash, **P. Balaprakash**, and D. Regener. Computational microstructure analyzing technique for quantitative characterization of shrinkage and gas pores in pressure die cast AZ91 magnesium alloys. *Journal of Computational Materials Science*, 32(3-4):480–488, 2005.

Book chapters

1. M. Birattari, Z. Yuan, **P. Balaprakash**, and T. Stützle. F-Race and iterated F-Race: An overview of racing algorithms for algorithm tuning and design. In T. Bartz-Beielstein et. al. (Eds.), *Empirical Methods for the Analysis of Optimization Algorithms*, Natural Computing Series, Germany, 2010. Springer Verlag. (In press)

2. **P. Balaprakash**, M. Birattari, and T. Stützle. Engineering stochastic local search algorithms: A case study in estimation-based local search for the probabilistic traveling salesman problem. In C. Cotta and J. van Hemert (Eds.), *Recent Advances in Evolutionary Computation for Combinatorial Optimization*, volume 153 of Studies in Computational Intelligence, pages 53–66, Berlin, Germany, 2008. Springer Verlag.

3. M. Birattari, **P. Balaprakash**, and M. Dorigo. The ACO/F-Race algorithm for combinatorial optimization under uncertainty. In K. F. Doerner et. al. (Eds.), *Metaheuristics - Progress in Complex Systems Optimization*, Operations Research/Computer Science Interfaces Series, pages 189–203, Berlin, Germany, 2006. Springer Verlag.

Theses

1. **P. Balaprakash**. Estimation-based metaheuristics for stochastic combinatorial optimization: Case studies in stochastic routing problems. Ph.D. thesis, Université Libre de Bruxelles, Belgium, 2010.

2. **P. Balaprakash**. Ant colony optimization under uncertainty. D.E.A. thesis, Université Libre de Bruxelles, Belgium, 2005.

3. **P. Balaprakash**. Preprocessing of stochastic Petri nets and an improved storage strategy for proxel based simulation. Master thesis, Otto-von-Guericke Universität Magdeburg, Germany, 2004.

Conference/workshop articles

1. **P. Balaprakash**, S. M. Wild, and B. Norris, SPAPT: Search Problems in Automatic Performance Tuning, Preprint ANL/MCS-P1872-0411, April 2011 (In review).

2. **P. Balaprakash**, S. M. Wild, and P. Hovland, Can search algorithms save large-scale automatic performance tuning? in Proceedings of the International Conference on Computational Science, ICCS 2011, Procedia Computer Science, Vol. 4, pp. 2136-2145, 2011.

3. M. Birattari, Z. Yuan, **P. Balaprakash**, T. Stützle. Automated algorithm tuning using F-races: Recent developments. In S. Voss and M. Caserta (Eds.) MIC 2009: Eighth Metaheuristics International Conference, July 13-16, 2009, Hamburg, Germany.

4. Z. Yuan, A. Fügenschuh, H. Homfeld, **P. Balaprakash**, T. Stützle, M. Schoch. Hybrid iterated constructive algorithms for scheduling locomotives in freight transport. In M. J. Blesa et. al. (Eds.) Hybrid Metaheuristics: Fifth International Workshop on Hybrid Metaheuristics, LNCS, 5296 pp. 102-116. Springer Verlag, Berlin, Germany.

5. **P. Balaprakash**, M. Birattari, T. Stützle, and M. Dorigo. Sampling strategies and local search for stochastic combinatorial optimization. In E. Ridge et. al. (Eds.) SLS-DS 2007: Doctoral Symposium on Engineering Stochastic Local Search Algorithms, pp. 16-20, September 6-8, 2007, Brussels, Belgium. [**Nominated for the best paper award**]

6. **P. Balaprakash**, M. Birattari, and T. Stützle. Improvement strategies for the F-Race algorithm: Sampling design and iterative refinement. In T. Bartz-Beielstein et. al. (Eds.) HM 2007: Fourth International Workshop on Hybrid Metaheuristics, LNCS, 4771 pp. 113-127. Springer Verlag, Berlin, Germany.

7. **P. Balaprakash**, M. Birattari, T. Stützle, and M. Dorigo. Incremental local search in ant colony optimization: Why it fails for the quadratic assignment problem. In M. Dorigo et. al. (Eds.) Ant Colony Optimization and Swarm Intelligence, Fifth International Workshop, ANTS 2006, LNCS 4150 pp. 156-166. Springer Verlag, Berlin, Germany.

8. M. Birattari, **P. Balaprakash**, and M. Dorigo. ACO/F-Race: Ant colony optimization and racing techniques for combinatorial optimization under uncertainty, In R. F. Hartl et. al. (Eds.) MIC 2005: Sixth Metaheuristics International Conference, August 22-26, 2005, Vienna, Austria.

9. D.G. Leo Prakash, **P. Balaprakash**, D. Regener. Computational microstructure analyzing technique for quantitative characterization of shrinkage and gas pores in pressure die cast AZ91 magnesium alloys. Thirteenth International Workshop on Computational Mechanics of Materials, September 22-23, 2003, Magdeburg, Germany.

Selected extended abstracts

1. **P. Balaprakash**, M. Birattari, T. Stützle, and M. Dorigo. Effective estimation-based stochastic local search algorithms for stochastic routing problems. In Schyns et. al. (Eds.), 24th Conference on Quantitative Methods for Decision Making, ORBEL 24, January 28-29, 2010, Liège, Belgium

2. **P. Balaprakash**, M. Birattari, T. Stützle, and M. Dorigo. Estimation-based stochastic local search algorithms for the stochastic routing problems. In E.-G. Talbi and K. Mellouli (Eds.) International Conference on Metaheuristics and Nature Inspired Computing, META'08, October 29-31, 2008, Hammamet, Tunisia.

3. G. di Tollo and **P. Balaprakash**. Index tracking by estimation-based local search. In A. Amendola (Eds.) Second International Workshop on Computational and Financial Econometrics, CFE'08, June 19-21, 2008, Neuchatel, Switzerland.

4. **P. Balaprakash**, M. Birattari, T. Stützle, and M. Dorigo. Applications of estimation-based SLS algorithms to stochastic routing problems. In P. Hansen and S. Voss (Eds.) Metaheuristics 2008, Second International Workshop on Model Based Metaheuristics, June 16-18, 2008, Bertinoro, Italy.

5. **P. Balaprakash**, M. Birattari, T. Stützle, and M. Dorigo. An experimental study of estimation-based metaheuristics for the probabilistic traveling salesman problem. In V. Maniezzo et. al. (Eds.) LION 2007 II: Learning and Intelligent Optimization, December 8-12, 2007, Trento, Italy.

6. M. Birattari, **P. Balaprakash**, T. Stützle, and M. Dorigo. Estimation-based local search for the probabilistic traveling salesman problem. In M. Gendreau et. al (Eds.) MIC 2007: Seventh Metaheuristics International Conference, June 25-29, 2007, Montreal, Canada.

Open-source software

1. ELS-PTSP: This software package provides a high performing implementation of the estimation-based iterative improvement algorithm to tackle the probabilistic traveling salesman problem. A key novelty of the proposed algorithm is that the cost difference between two neighbor solutions is estimated by partial evaluation. Moreover, the proposed algorithm exploits the well known TSP neighborhood reduction techniques to speed up the search. Developed in C with GNU scientific library under Linux. Available at `http://els-ptsp.googlecode.com`